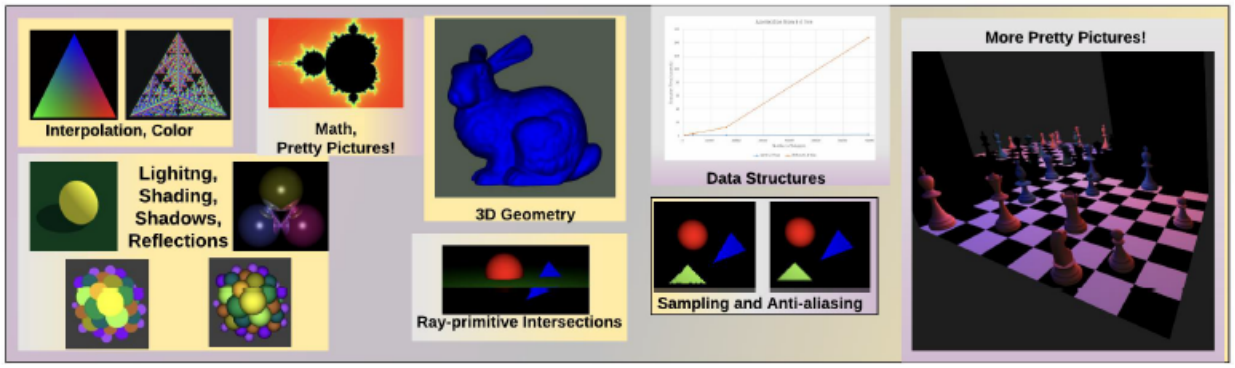
Habib University
shaping futures

Computer Graphics

CS 440 S1
Fall Semester 2022

"All problems in computer graphics can be solved with a matrix inversion." - Jim Blinn



Course Information

Class Location: FF-W242
Class Meeting Time(s): Mon Thurs (03:50 PM-05:05 PM)
Course Prerequisites: CS 201,CS/CE 224/272,MATH 205
Hardware/Software Prerequisites (if any): a LaTeX compiler, Zoom, 2 different recent web browsers, a recent C++ compiler, Computer with mic, camera, and Internet connection
Content Area: This course fulfills the requirements of a CS Elective.

Instructor Information

Instructor: Waqar Saleem
Title: Associate Professor
Office Location: C-122
Email: waqar.saleem@sse.habib.edu.pk

Office Hours: Tue, Wed, Thu: 1130-13h

Additional Information

Hello and welcome to the Fall 2022 offering of CS 440 Computer Graphics. My name is Waqar Saleem and I shall be your instructor. I am happy to discuss the course and your queries in person. I sit in C-122 where I shall expect to meet you in my students hours mentioned above. If these times do not suit you, please make an appointment.

You may prefer the fluidity of cyberspace to the confines of 4D space. So do I! My email address is linked above but for course matters, please message me on Canvas. I am online most of the time so will respond quickly. Once in a while, I get the urge (or my family manages to convince me) to have a life outside university. If you happen to catch me in that phase, I may not respond outside working hours. To keep it safe, please allow me up to 2 working days to respond. If you still have not heard back from me, I may have finally succeeded in completely transitioning my existence to cyberspace. But send me a reminder just in case.

I am excited about this course and hope you are, too! It is going to be fun. You may not realize it through the sweat and tears as we journey through the course, but you will once you look back at it. But I trust that you know this already.

Course Description

Computers produce cool, fantastic images. You already know that! As with all things computers, there is deep method to what we have grown to take for granted. In this case, there is math, problem solving, data structures, algorithms, programming, an understanding of natural phenomena, and much more. The sheer ingenuity with which computer graphics brings these elements together is no less awesome than the images it creates.

This course will dive into this awesomeness. And instead of spoiling, lifting the veil and going behind the scenes will only add to our appreciation of computer graphics.

Course Aims

Through this course, you will understand computer graphics as an exercise in rendering. You will learn about common domain parlance and techniques, e.g. a computer graphics system, the graphics pipeline, a graphics API, spatial partitioning, shading. Computer graphics has developed several

rendering techniques. In this course, you will learn about two of them: pipeline rendering and ray tracing.

We will gain hands-on experience with all the above and in the process, we will appreciate the fruitful union of mathematics and computer science in enabling computer graphics.

Computer graphics is an immensely rich field, its ingenuity fueled by the passion of the countless, immensely gifted and creative people who contribute to it. There is no dearth of material related to Computer Graphics. This course will only scratch the surface and initiate you on what will hopefully be a lifelong journey into the intricacies of Computer Graphics. We will happily jump on interesting tangents as they come up while being mindful of our formal course learning outcomes.

Course Learning Outcomes (CLOs)

Below are this course's learning outcomes accompanied by the cognition level [2] at which each will be attained.

	CLO	Description	Cognition
1	Fundamentals	Create 2D scenes through the application of fundamental computer graphics principles	Cog-6
2	Geometry	Correctly parse the geometry represented in common 3D formats	Cog-3
3	Transformations	Apply viewing transformations to a given 3D scene	Cog-3
4	Ray tracing	For a given 3D scene, create its ray traced rendering which is accelerated using space partitioning structures	Cog-6
5	Collaboration	Collaborate fruitfully on the creation and development of solutions to problems related to the above	Aff-3

The graphics API used in this course is WebGL 1.0 and the implementation language for the ray tracer is C++.

[2] What are the three domains of Bloom's Taxonomy?, Educere Centre;
Bloom's Revised Taxonomy: Cognitive, Affective, and Psychomotor, Arkansas State University;

Bloom's Taxonomy, Centre for Teaching Excellence, University of Waterloo.
All links last accessed on 19 Aug, 2021.

Format and Procedures

This is a 400 level course of 3 credit hours. The content and course work draw heavily on the prerequisite courses. The rule of thumb for out-of-class time for a course is at least 2 hours of work outside class for every credit hour. In a previous iteration of this course, students reported spending an average of 8 per week outside of class-time for this course. This may vary based on your command of the prerequisite courses.

You must be attentive in lectures and do the assignments in a timely manner. I will make all efforts to closely follow the course textbooks so that you have ready references. Make sure to avail your student hours immediately if you are falling behind. You must attend your weekly recitation which will provide complementary coverage of the used tools and deeper insight into the topics currently under discussion.

Teamwork A lot of coursework will be in teams. Please be honest toward your team and contribute fairly. You will be providing feedback on your team work.

Peer Review Taking a 400 level course, you can now maturely review and assess your peers' work, learn from it, and provide constructive feedback on it. We will be doing that for our assessments.

Viva Submission of homework assignments is in teams and may be followed up by a team viva called by the instructor. A viva will be called as necessary and need not apply to all groups or all assessments.

Punctuality Please respect deadlines. Submit your work by the indicated time. Incomplete work will receive partial credit, late work will receive no credit.

Contesting marks Concerns regarding a score can be reported up to a week after its release. Concerns raised later cannot be entertained.

Grace marks Requests for grace marks for whatever reason will not be entertained and each such request will result in a penalty of 1% from your overall score.

Behavior You are expected to maintain a behavior befitting Yohsin and acknowledging the classroom as a place of learning, exploration, and experimentation. The University's standard policies on attendance, inclusivity, student hours, and academic integrity apply in this course. These are described further below.

Other course norms, e.g. for online participation, will emerge as the course proceeds. I am confident that as long as we view the class as a communal learning project and respect each other, no

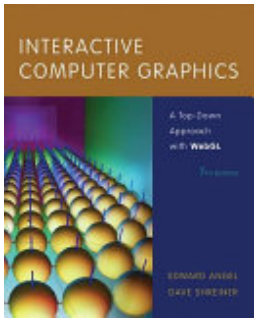
undesired behavior will occur. Should it occur, I will notify you discreetly and we will figure it out.

Mode of Instruction

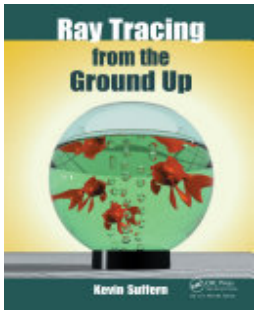
Instruction in higher education all over the world has vacillated unpredictably between in-person and online for more than two years, leading to at least one important lesson. We do not like remote, online learning or instruction. To every extent possible, this course will take place in person. We will meet twice a week for 50-minute lectures and once a week for a 3-hour lab.

In the unfortunate circumstance where we need to go online, relevant instructions will be shared accordingly. For that contingency, you should have a computer with an internet connection that is capable of running a latest browser version and Zoom.

Required Texts and Materials



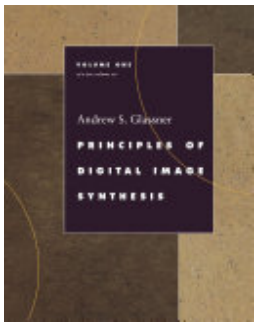
Interactive Computer Graphics
Subtitle: A Top-Down Approach Using WebGL
Edition: 7th
Authors: Edward Angel
ANGEL & Shreiner, Interactive Computer Graphics: A Top-Down Approach with WebGL | Pearson



Ray Tracing from the Ground Up
Authors: Kevin Suffern
Test Page for the Apache HTTP Server on Red Hat Enterprise Linux (raytracegroundup.com)

Optional Materials

Principles of Digital Image Synthesis
Authors: Andrew S. Glassner
Volume 1 and Volume 2 freely available.



Principles of digital image synthesis: Vol. 1 - Andrew S. Glassner - Google Books

Principles of Digital Image Synthesis - Andrew S. Glassner - Google Books

Physically Based Rendering
Subtitle: From Theory To Implementation
Authors: Matt Pharr, Wenzel Jakob, Greg Humphreys
Physically Based Rendering: From Theory to Implementation (pbrt.org)

The Internet Ray Tracing Competition
The Internet Ray Tracing Competition Archive (irtc.org)

Assessments

Your final grade in this course will be computed as follows.

Instrument	%	Remarks
Homework (4)	35	These will be attempted in pairs and your submissions will be peer-reviewed in a double blind manner. Release and submission will be over GitHub.
Quizzes	5	These are online quizzes on Canvas of open duration to be attempted individually.
Project I	15	This culminates the pipeline rendering module. You work in a team of 4 and use WebGL to program a flight simulator.
Project II	20	This culminates the course. You work in a team of 4 and raytrace a cool scene which you present to the class.
Recitation	5	Supporting instruction is provided in recitations.
Render Jam	10	Show off your renders any 2 weeks of the semester.
Cool stuff	10	Present what you find cool about CG.

You may be called in by the course staff for a viva on your submission for any of the assessments. Your performance on the viva will affect your earned score on the assessment.

Grading Scale

Letter Grade	GPA Points	Percentage
A+	4.00	[95-100]
A	4.00	[90-95)
A-	3.67	[85-90)
B+	3.33	[80-85)
B	3.00	[75-80)
B-	2.67	[70-75)
C+	2.33	[67-70)
C	2.00	[63-67)
C-	1.67	[60-63)
F	0.00	[0, 60]

Note: [*a*, *b*) is a range of numbers from *a* to *b* where *a* is included in the range and *b* is not.

Week-Wise Schedule (Tentative)

The schedule may change in view of class progress as the semester proceeds. All indicated chapters under Reading are from the course text books. See the Live Syllabus for an updated version.

Week	Start	End	Topics	Reading	Recitation	Notes
1	22-Aug	26-Aug	Introduction to the course		WebGL: first program	HW 1: Math & JS
2	29-Aug	2-Sep	Imaging	Angel,1.2 - 1.4	WebGL: attributes and viewing	
3	5-Sep	9-Sep	Graphics Pipeline		WebGL: shaders	HW 1 due
4	12-Sep	16-Sep	Affine Geometry	Angel (Section 4.1, 4.3)	WebGL: animation & interaction	HW 2: 2D Graphics
5	19-Sep	23-Sep	Representation of Geometry, Transformations	Angel (Section 4.1, 4.3)	WebGL: transformations	
6	26-Sep	30-Sep	Transformations in WebGL, Mesh Data Structures	Angel (Section 4.2)		HW 2 due
7	3-Oct	7-Oct	Model View Transformation, Projection Normalization	Angel (Section 5.1 - 5.3)		HW 3: Interaction & 3D

Week	Start	End	Topics	Reading	Recitation	Notes
8	10-Oct	14-Oct	Viewing Projections, Perspective Viewing	Angel (Section 5.4 - 5.7)		
9	17-Oct	21-Oct	Viewing Projections, Perspective Viewing	Angel (Section 5.4 - 5.7)		Monday off; HW 3 due Proj I: Flight Simulator
10	24-Oct	28-Oct	Lighting and Shading, Polygon Shading, Bump and normal maps	Angel (Section 6.1 - 6.3)		
11	31-Oct	4-Nov	Clipping, Rasterization and Fragment Processing	Angel (Section 8.2 - 8.10)		Proj I due; HW 4: Raytracing engine; Proj II: Raytracing showcase
12	7-Nov	11-Nov	Ray-Primitve Intersections, Sampling	Suffern, Chapters 3, 5, 19		
13	14-Nov	18-Nov	Acceleration Structures, Rendering Equation	Suffern, Chapters 13, 22		HW 4 due
14	21-Nov	25-Nov	Anti-aliasing	Suffern, Chapter 4		
15	28-Nov	2-Dec	Depth of Field	Suffern, Chapter 10		
Finals			Raytracing showcase			P II due

Late Submission Policy

Due to teamwork and peer review, many components of the course, especially the assessments, are tightly coupled. A single delay can have a cascading affect on the scores of the entire class. Therefore, please observe the deadline prescribed for each assessment. There is no late submission policy. It is better to submit partial work on time and receive partial credit than to submit complete work late and receive no credit. In order to avoid last minute emergencies, e.g. power failure close to the deadline, start your work early and aim to finish it in advance of the deadline.

We will mostly be using automated tools which time-stamp your submission or simply block submission after the deadline. Please be mindful of deadlines and discuss with me beforehand if you

foresee any issues.

Academic Integrity

Each student in this course is expected to abide by the Habib University Student Honor Code of Academic Integrity. Any work submitted by a student in this course for academic credit will be the student's own work.

Scholastic dishonesty shall be considered a serious violation of these rules and regulations and is subject to strict disciplinary action as prescribed by Habib University regulations and policies. Scholastic dishonesty includes, but is not limited to, cheating on exams, plagiarism on assignments, and collusion.

a. Plagiarism: Plagiarism is the act of taking the work created by another person or entity and presenting it as one's own for the purpose of personal gain or of obtaining academic credit. As per University policy, plagiarism includes the submission of or incorporation of the work of others without acknowledging its provenance or giving due credit according to established academic practices. This includes the submission of material that has been appropriated,// bought, received as a gift, downloaded, or obtained by any other means. Students must not, unless they have been granted permission from all faculty members concerned, submit the same assignment or project for academic credit for different courses.
b. Cheating: The term cheating shall refer to the use of or obtaining of unauthorized information in order to obtain personal benefit or academic credit.
c. Collusion: Collusion is the act of providing unauthorized assistance to one or more person or of not taking the appropriate precautions against doing so.

All violations of academic integrity will also be immediately reported to the Student Conduct Office.

You are encouraged to study together and to discuss information and concepts covered in lecture and the sections with other students. You can give "consulting" help to or receive "consulting" help from such students. However, this permissible cooperation should never involve one student having possession of a copy of all or part of work done by someone else, in the form of an e-mail, an e-mail attachment file, a diskette, or a hard copy.

Should copying occur, the student who copied work from another student and the student who gave material to be copied will both be in violation of the Student Code of Conduct.

During examinations, you must do your own work. Talking or discussion is not permitted during the examinations, nor may you compare papers, copy from others, or collaborate in any way. Any collaborative behavior during the examinations will result in failure of the exam, and may lead to failure of the course and University disciplinary action.

Penalty for violation of this Code can also be extended to include failure of the course and University disciplinary action.

For this course, collaboration is allowed in the following instances: Homework assignments, Projects, Render Jam, and Cool Stuff.

Attendance Policy

You are expected to attend and participate in all lectures and recitations. Under extenuating circumstances, you may miss up to 04 lecture sessions and up to 02 recitation sessions. In case of a missed session, you must inform me with the reason. Failing to do so may raise an early academic alert with the Office of Academic Performance (OAP). Excessive absences will lead to an automatic withdrawal from the course.

Accommodations for Students with Disabilities

In compliance with the Habib University policy and equal access laws, I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first two weeks of the semester, except for unusual circumstances, so arrangements can be made. Students are encouraged to register with the Office of Academic Performance to verify their eligibility for appropriate accommodations.

Inclusivity Statement

We understand that our members represent a rich variety of backgrounds and perspectives. Habib University is committed to providing an atmosphere for learning that respects diversity. While working together to build this community we ask all members to:

- share their unique experiences, values and beliefs
- be open to the views of others
- honor the uniqueness of their colleagues
- appreciate the opportunity that we have to learn from each other in this community
- value each other’s opinions and communicate in a respectful manner
- keep confidential discussions that the community has of a personal (or professional) nature
- use this opportunity together to discuss ways in which we can create an inclusive environment in this course and across the Habib community

Office Hours Policy

Every student enrolled in this course must meet individually with the course instructor during course office hours at least once during the semester. The first meeting should happen within the first five weeks of the semester but must occur before midterms. Any student who does not meet with the instructor may face a grade reduction or other penalties at the discretion of the instructor and will have an academic hold placed by the Registrar's Office.

Program Learning Outcomes (For Administrative Review)

Upon graduation, students will have the following abilities:

- PLO 1: Analysis: Analyse a given situation and reduce it to one or more problems that can be solved via computer intervention.
- PLO 3: Programming: Program a given solution in a variety of programming languages belonging to different paradigm.
- PLO 4: Implementation: Design and implement software systems of varying complexity.
- PLO 6: Self-learning: Research, learn, and apply requirements needed to implement a solution for a given high level problem description.
- PLO 8: Communication and Teamwork: Work effectively in inter-disciplinary teams.

Recording Policy

Only asynchronous and synchronous online sessions will be recorded and uploaded on our Video Management System (Panopto). Link to the folder of recordings will be available to all students. Hyflex classes might be recorded if faculty deems it appropriate.

Program Learning Outcomes (PLOs) mapped to Course Learning Outcomes (CLOs)	
	CLOs of the course are designed to cater following PLOs: **PLO 1: Analysis** **PLO 3: Programming** **PLO 4: Implementation** **PLO 6: Self-learning** **PLO 8: Communication and Teamwork**

	Distribution of CLO weightages for each PLO				
	CLO 1	**CLO 2**	**CLO 3**	**CLO 4**	**CLO 5**
PLO 1	25%	25%	25%	25%	
PLO 3	25%	25%	25%	25%	
PLO 4	25%	25%	25%	25%	
PLO 6		33%	33%	34%	
PLO 8					100%

Mapping of Assessments to CLOs

Assignments	CLO #01	CLO #02	CLO #03	CLO #04	CLO #05